Long-Wave Infrared Optical Cross Section Measurements of Biological Warfare Agents

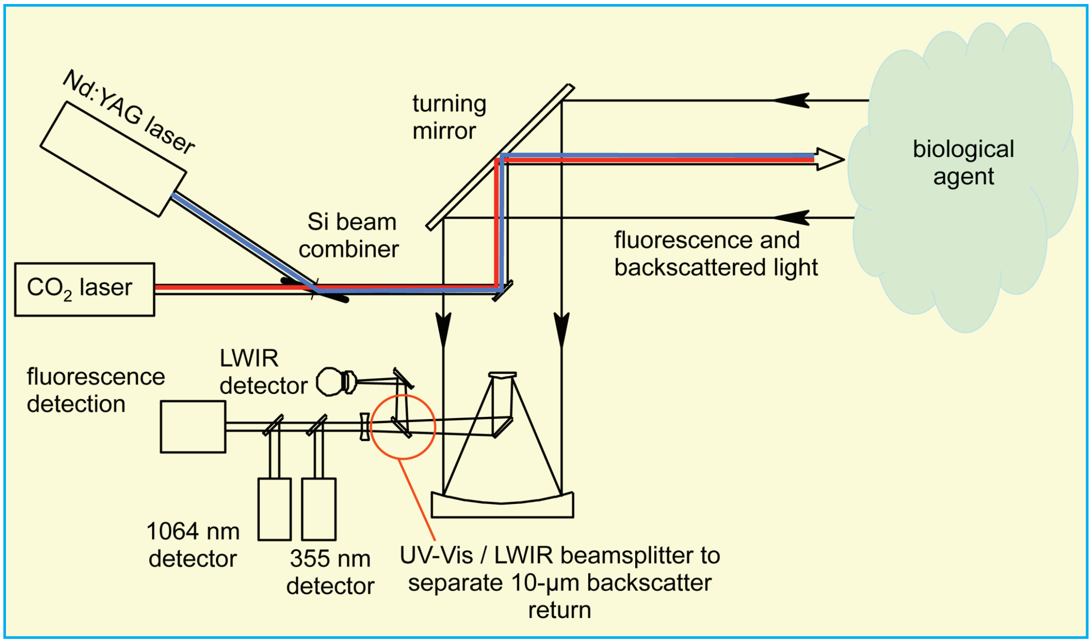

Figure 1: Schematic diagram of the new multi-wavelength range-resolved LIDAR to detect biological warfare aerosol agents.

A new multi-wavelength, range-resolved LIDAR system expands Sandia's remote sensing capabilities

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LIDAR (Light Detection and Ranging) systems are now a key component in the Department of Defense (DoD) strategy to protect troops from biological weapons on the battlefield. A LIDAR is a laser optical system capable of detecting aerosol clouds from a remote distance. Analysis of the return signal can determine if the detected aerosol clouds are hazardous biological warfare agents, or simply harmless dust, pollen, or engine exhaust. These "standoff" detection systems can only be tested against aerosol clouds of biological simulants, not against the real threat agents. Thus field test optical backscatter and laser-induced fluorescence data is collected on simulant clouds and the performance is calculated using optical cross section values for the simulants and threat agents.

Recently, Sandia has added optical cross section measurement capability in the long-wave infrared (LWIR) region of 9.3-10.7 μm, a key wavelength region for a biological system now under consideration by the DoD. A tunable, pulsed CO_2 laser, programmed to tune over nineteen discrete wavelengths in the 9.3-10.7 μm region, was added to the Sandia LIDAR facility (a trailer that can be moved to remote locations). One of the major challenges in making the LWIR cross section measurements was that cross sections at visible and near infrared (NIR) laser wavelengths also had to be measured at the same time. The multiple wavelengths required a new beam combiner for the out-going lasers that was able to transmit (coaxially) 355 nm, 1064 nm, and 9.2-10.7 μm laser radiation, and a new receiving wavelength separator to send the returning signals to the wavelength appropriate detectors. An optical-grade Si wafer was used to combine the outgoing laser beams. The LWIR beam from the tunable CO_2 laser was transmitted through the Si wafer at Brewster's angle while the 1064- and 355-nm beams from the Nd:YAG laser were reflected from it. On the receiver, a custom dielectric coating was used to separate the LWIR return from the other wavelengths. Figure 1 is a schematic of the redesigned optical layout.

To measure agent cross sections, Sandia researchers first collect standoff LIDAR data for aerosol clouds of simulants released in a controlled outdoor facility. After calibration of the LIDAR system, they calculate the optical cross sections of these simulant aerosols. Next, they measure the optical response at all of the wavelengths of the simulant materials and actual threat agents contained in specially-designed stainless steel cuvettes (shown in Figure 2), having a ZnSe window on one side for LWIR optical access and a fused silica window on the other side for UV–NIR optical access. Finally, they compute the agent cross sections by comparing their optical signals relative to that of the simulants using the knowledge gained earlier. It should be noted that the LIDAR trailer is capable of propagating laser radiation for both stand-off field measurements and, after minimal reconfiguration, performing in-trailer measurements on the same materials contained in sample cuvettes with the same laser sources and detectors.

In this way, Sandia will determine the elastic backscatter optical cross sections at twenty-one separate wavelengths, as well as the fluorescence cross sections excited at 355 nm for twenty-four different biological simulants and eight threat agents. These optical cross section values will then be delivered to a DoD customer by early 2010, and will allow the DoD Joint Biological Standoff Detection Systems program to evaluate performance of proposed LIDAR systems to protect troops from biological weapons on the battlefield. This project is a good example of how Sandia laser and optical science expertise and facilities are being used to support a national (engineering) program to develop defenses against biological weapons.

Figure 2: Specially-designed stainless steel cuvette with ZnSe window for LWIR wavelengths and a fused silica window for UV–NIR wavelengths.